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The Effect of Regular Exercise on Reproductive Hormones in Male Athletes

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ABSTRACT

Objective: The effects of regular exercise on hormones have been subject of many research and as a result, the idea that hormonal changes respond to physical activity by metabolic and endocrine adaptation has gained weight. However, it was observed that studies conducted in male groups might be inadequate in terms of hormone profile determination. The purpose of the study is to examine the effects of regular exercise on blood levels of reproductive hormones.

Material and Methods: In the study, follicle stimulating hormone (FSH), luteinizing hormone (LH), estradiol, total testosterone, thyroid stimulating hormone (TSH) and prolactin levels that are effective in reproductive function were examined in 40 males (20 sedentary subjects, 20 athletes). Findings were analysed by independent t-test, and values diverging beyond the $p<0.05$ level were accepted as significantly different.

Results: According to the results, it was determined that estradiol was significantly higher (30.9 ± 13.4 pg/ml) and LH lower (3.76 ± 0.65 mU/ml) in sedentary ($p<0.05$). There was no statistically significant differences in total testosterone, TSH, FSH and prolactin hormone levels between groups.

Conclusion: According to these findings, we suggest that regular exercise programmes may affect some male reproductive hormones.

Keywords: Reproductive hormones, gonadotropins, exercise

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Erkek Sporcularda Düzenli Egzersizin Endojen Üreme Hormonları Üzerine Etkisi

ÖZ

Amaç: Düzenli yapılan fiziksel aktivitelerin hormonlar üzerine olan etkisi birçok araştırmanın konusu olmuştur ve bu araştırmaların sonucunda, hormonal değişimlerin fiziksel aktiviteye metabolik ve endokrin adaptasyonla karşılık verdiği fikri ağırlık kazanmıştır. Ancak; çalışmaların çoğunlukla kadınlar üzerinde yoğunlaştığı, erkek gruplarındaki çalışmaların hormon profili belirleme yönüyle yetersiz olduğu gözlenmektedir. Bu bağlamda sunulan çalışmanın amacı düzenli olarak uygulanan aerobik egzersizin erkeklerde üreme hormonlarına etkisinin incelenmesidir.

Gereç ve Yöntemler: Çalışmada 18-25 yaş grubundaki 40 erkeğin (20 sedanter, 20 sporcu) üreme fonksiyonlarında etkili olan follikül stimüle edici hormon (FSH), lüteinleştirici hormon (LH), östradiol, total testosteron, tiroid stimüle edici hormon (TSH) ve prolaktin düzeylerine bakıldı. Elde edilen bulgular bağımsız örneklem t-testi ile analiz edilerek $p<0.05$ düzeyindeki değerler anlamlı kabul edildi.

Bulgular: Analiz sonuçlarına göre sedanterlerde östradiolün anlamlı düzeyde yüksek olduğu (30.9 ± 13.4 pg/ml), LH'ın ise düşük (3.76 ± 0.65 mU/ml) olduğu tespit edildi ($p<0.05$). Total testosteron, TSH, FSH ve prolaktin hormonlarında ise istatistiksel olarak anlamlı düzeyde farklılık saptanmadı.

Sonuç: Elde edilen bulgulara göre düzenli uygulanan egzersiz programlarının endokrin sistemi etkileyerek erkek üreme hormonları üzerinde kısmen etkili olabileceği söylenebilir.

Anahtar Sözcükler: Üreme hormonları, gonadotropinler, egzersiz

INTRODUCTION

Physical activity has become a common life style among the most developed populations due to the many benefits it provides. Athletes are exposed to the same causes of infertility as men in the general population. However, in this very specific population, sporting practice itself may become a possible cause of infertility. In this equation, the type of physical activity and various natural parameters (such as volume, intensity, frequency, level of repeat and organization) are important variables (1). The endocrine system plays a key role in the regulation of almost all body activities including reproduction, growth, development, behavior, and water-electrolyte balance (2).

In addition, hormones are regulatory molecules that control reproduction, energy production and maintain its storage. Reproductive and endocrine systems are particularly susceptible to the training stress of an athlete, and unfortunately malfunctions occur in these systems under excessive stress. Steroid hormones not only regulate reproductive functions, but also heavily impact the nervous, skeletal, and cardiovascular systems (3). The effects of regular exercise on hormone secretion are nowadays an important aspect of sports medicine and physiology research (4). Exercise, depending on its intensity, creates several stress conditions in the body, which results in the changes in cortisol hormone secretion levels that overall effects the hormonal balance (5). Exercise is closely related to the changes in the levels of metabolites and hormones in the body (6). Previous studies have shown that the endocrine and metabolic adaptation in the body against the effects of physical activity results in hormonal changes (7). Furthermore, animal and human studies indicated that steroid hormone levels in skeletal muscle increase with acute and chronic exercise stimulation (8).

As part of the reproductive function, spermatogenesis in men continuously takes place and is under the influence of luteinizing hormone (LH) and follicle stimulating hormone (FSH) secreted by the frontal lobe of the pituitary. Among these hormones, LH stimulates testosterone release, which together with FSH initiates sperm production and maintains it (9). In the literature, the common regulatory pathways that control energy homeostasis and reproductive function have so far not been understood due to limited studies or uncertain data (10). The acute response of the endocrine system to endurance exercise is related to the intensity and duration of the specific training stimulation (11,12). Therefore, studies have mostly investigated acute responses before and after exercise (13,14). However, studies conducted to determine the effect of long-term exercise on the athlete profile have been shown to be insufficient, and the present research project will contribute to the elimination of this deficit.

In this context, the aim of the research project is to examine the effects of regular exercise on blood levels of FSH, LH, estradiol, total testosterone, thyroid stimulating hormone (TSH) and prolactin, and to determine the reproductive hormone profiles of athletes.

MATERIAL and METHODS

Research subjects consisted of an exercise group that regularly trained 1.5 hours daily, four days per week to develop strength, endurance and speed (professional football players, n = 20, age: 22.9 ± 1.4 yrs) and a sedentary group (n = 20, age: 19.1 ± 1.9 yrs). All measurements were performed after a six months' training period. For six months, athletes and sedentary subjects have never received any nutritional supplements. The body mass indices (BMI) of the volunteers were calculated according to the formula *"BMI = Body weight (kg) / [height (m)]^2".* Participants' productive hormone levels, namely testosterone, FSH, LH, prolactin, estradiol, and TSH were obtained from blood serum. Participants were informed in advance that they should not consume any liquid or solid food before the blood test. On specified dates and times, the 40 participants were taken to the hospital in four groups, at the same time of the day. Volunteers were chosen among subjects who fulfilled the following criteria: to be free from any illness or severe disabilities, not having surgery within the last six months, to be non-smoker, aged 18-25 years old, and non-user of any medication that would affect hormonal regulation.

All procedures were approved by the Ondokuz Mayıs University Human Ethics Committee (OMU KAEK; 2015/290). All the athletes and sedentary control group subjects signed a "voluntary consent statement form" to participate in the study. The Helsinki Declaration was followed in all procedures during the study.

Biochemical Analyses

Participants' blood samples biochemical analyses were performed at the hospital laboratory. About 10 ml of blood was taken from all participants between 9:00 am to 10:00 am from an forearm elbow vein. The blood was transferred from the syringe to a red capped, vacuumed biochemical test tube that does not contain anticoagulants and was allowed to clot. Following blood clotting, the whole blood samples were centrifuged at 4000 rpm for 15 min at +4°C on an Abbott Architect I1000 SR (USA) centrifuge to separate the serum. Serum hormone levels were examined through ELISA kits, and group results were compared.

Statistical Analysis

The statistical package program of IBM SPSS (version 19, Statistics / IBM Corp, Chicago IL, USA) was used to evaluate the data. For descriptive statistics, arithmetic means and standard deviation (SD) of the data was calculated, and the level $p<0.05$ was considered significant. In order to determine the statistical method to be used for the obtained data, a normality test was applied firstly. As a result of the Shapiro-Wilk test, the data was shown to have normal distribution ($p>0.05$). Findings were analyzed by the independent sample t-test, and the results were compared.

RESULTS

Although some had high SD figures, all measured hormonal levels of the subjects participating in the study were within the normal reference interval. Mean and standard deviation values for age, height, body weight and BMI of the groups are shown in Table 1. Mean and standard deviation findings of serum hormone levels for the athletes and the sedentary group, and the independent sample t-tests that compared these levels are given in Table 2.

Findings of the research indicated that estradiol and LH levels were found to be significantly higher in the sedentary group. In addition, group comparison statistics revealed that mean values for all hormones except TSH were higher in the sedentary group (Table 2).

Table 1. Average age, height and body weight of sedentary subjects and athletes

Groups	**Age** (yr)	**Height** (m)	**Body weight** (kg)	**BMI** (kg/m^2)
Sedentary (n=20)	22.9 ± 1.4	1.77 ± 0.04	76.9 ± 7.8	21.2 ± 2.0
Athletes (n=20)	19.1 ± 1.9	1.74 ± 0.05	71.0 ± 6.5	19.9 ± 2.2

BMI: Body mass index; figures as (mean ± SD); SD: standard deviation

Table 2. Hormone levels and independent sample t-test comparisons of the groups

Parameters	**Sedentary** (n=20)	**Athletes** (n=20)	**p**
Estradiol (pg/ml)	30.9 ± 13.4	24.5 ± 14.1	0.027*
FSH (mU/ml)	2.84 ± 3.01	2.65 ± 0.70	0.663
LH (mU/ml)	3.76 ± 0.65	3.00 ± 1.25	0.040*
Prolactin (ng/ml)	12.3 ± 10.7	11.6 ± 3.35	0.730
Total testosterone (ng/dl)	498.3 ± 411.5	444.2 ± 424.0	0.319
TSH (μU/ml)	1.42 ± 0.06	1.68 ± 0.14	0.288

*: $p<0.05$; FSH: follicle stimulating hormone; LH: luteinizing hormone; TSH: thyroid stimulating hormone; mU/ml: milli units/ml; μU/ml: microunit/ml; figures as (mean ± SD); SD: standard deviation

DISCUSSION

The present study aimed to examine the reproductive profiles of male athletes who exercise regularly. The homogeneity of the groups that participated in the study was expressed by revealing that the data regarding age and body weights had normal distribution (Table 1). Normal distribution of groups' data is important in terms of objectivity of the study. According to the results of the analysis in the present study, only estradiol and LH serum hormone levels were found to be statistically significantly higher in the sedentary group.

The effect of physical activity on hormones has been the subject of many investigations previously, and the idea that hormonal changes would result from metabolic and endocrine adaptation to physical activity has been supported (7).

In the literature, it has been reported that exercise can change the levels of some hormones and enzymes in the body as a stress factor (1,14,15). It is expected that within this system, exercise also affects the hormones related to the reproductive system, which is supported by studies in the literature. For instance, a study that investigated the effects of six month-long physical exercise on plasma testosterone and LH levels revealed that these hormone levels were increased by 21% and 25% respectively. It was stated in this study that exercise induces hormonal changes, affecting metabolic and endocrine adaptation in the organism (7). In a similar study, the effect of exercise on reproductive hormones was investigated in older males. This study (16) displayed that physical exercise affects LH and testosterone levels in men, which are in part parallel to the findings of the presented study.

On the other hand, it was also shown that findings related to the effects of exercise on reproductive hormones were diversified. While some studies indicated that exercise results in increased reproductive activity and hormone levels, others (17,18) pointed to opposite results or no significant correlation (19,20). For example, an increase in testosterone hormone level with physical activity was observed in a study (20). A separate study also reported elevated testosterone levels in sprint runners (21). Adversely, it was determined in a study that exercise reduced free testosterone levels (22). Gulledge and Hackney found no significant differences between the levels of sex hormone-binding globulin, LH, cortisol and prolactin in exercising and sedentary groups; whereas three different studies concluded that testosterone was significantly lower in the exercise group. LH, cortisol, and prolactin levels were not found to be statistically significantly different among the groups (23). It was stated that differences in several variables or sample selection (e.g. diseases or drug usage), as well as the type and severity of exercise can cause obtaining diversified findings in view of the exercise-reproductive hormone relationship. The present study required the subjects to be free of any chronic disease and medication usage that could affect the hormonal system.

It is likely that the findings are affected by the intensity and severity of regular training in the athlete group, as the relationship between exercise and endocrine system, especially the reproductive one, is known to be extremely sensitive to the severity of exercise. Exercise creates some very useful changes in the human body; however, intense training could result in excessive pressure on the organism that causes physiological incompatibilities and other harmful consequences (24).

Lack of physical exercise also affects reproductive functions and depending on the type, severity, and duration of the exercise, changes biochemical parameter levels are known to occur (1). A study reported that the pituitary could not respond to the reduction in testosterone levels resulting from mental and physical stress (25). This is evidenced by serum testosterone level decreases in some athletes after heavy endurance training, but no change in LH and FSH levels (26). Hence, the intensity of exercise has affected reproductive hormones at different levels. Although the expected normal physiological reaction is that LH hormone secreted by the pituitary gland increases testosterone secretion from the Leydig cells, FSH hormone secreted by the pituitary leads to sperm production in the seminiferous tubules (27). The secreted testosterone reduces LH secretion from the pituitary (28). However, it is reported that the reason for not observing the expected reaction could be the intensity of the exercise. There is a similar situation in the study presented, in which the independently high or low levels of LH and estradiol can be explained by the fact that the participating group is selected from a regularly exercising population.

In the present study, it was found that the athletes had lower BMI values than the sedentary group, within the normal range. It is expected that body weight decreases with regular exercise. However, it has been reported in the literature that the body mass index can change the testicular environment in a way that would affect normal sperm production and health (29).

In addition, not all of the cohort studies in the literature involving specific associations between semen parameters and obesity are consistent. While some data have pointed out to correlations between abnormal sperm count, morphology or motility and obesity (29); others have declared no negative effects of higher BMI (30,31). Though the changes in male reproductive hormones with increased adiposity are evident, the effects on sperm count and overall health have not been clarified (29). In light of these data; the limit of the present study is that the relationship between findings and BMI levels are not examined. It would be an important contribution to body weight and hormonal adaptation studies to determine whether the findings are affected by regular exercise or low BMI values.

CONCLUSIONS

The present study reports that regular exercise may cause differences in some hormonal levels between athletes and the sedentary group, which could affect the neuroendocrine system. The findings of the present study indicate that this effect is observed not because of pathological events, but that the hormonal changes most likely occur due to metabolic and endocrine adaptations in response to physical activity. In the present study, the absence of sperm quality and hypothalamic-pituitary-adrenal axis findings constitutes a limitation. However, it can be concluded that findings related to reproductive hormones will help to interpret research in these areas. In addition, studies with higher number of participants may support the findings more strongly.

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REFERENCES

1. Du Plessis SS, Kashou A, Vaamonde D, et al. Is there a link between exercise and male factor infertility. *Open Reprod Sci J.* 2011;3:105-13.
2. Guyton AC, Hall JE. *Medical Physiology*. 9th ed. Çavuşoğlu H, çeviri editörü. İstanbul: Nobel Tıp Kitabevleri; 1996. p. 4-1036.
3. Güncü NG, Tözüm TF. The effects of estrogen, progesterone and testosterone on periodontal tissues. *J Gazi University Faculty of Dentistry.* 2005; 22:121-7.
4. Pope HG Jr, Kouri EM, Hudson JI. Effects of supraphysiologic doses of testosterone on mood and aggression in normal men: a randomized controlled trial. *Arch Gen Psychiatry.* 2000;57:133-40.
5. Çakmakcı O, Keçeci T, Patlar S. Effects of glycerol supplementation on epinephrine and cortisol in sportsmen and sedentary (Title corrected). *J Phys Educ Sports Sci.* 2009;3:160-8.
6. Kayacan Y, Kaya Y, Makaracı Y. Excretion of creatinine, uric acid and microproteins by general body massage applied after exercise. *Eur J Phys Educ Sport Sci.* 2017;3(6):36-47. doi: 10.5281/zenodo.58377.
7. Tokuçoğlu H, Kayıgil Ö, Deniz N, et al. Testosterone, estrogen, prolactin, follicle stimulating hormone and luteinizing hormone levels before and after exercise in female and male athletes. *Gazi Med J.* 1992;3:77-80.
8. Sato K, Iemitsu M. Exercise and sex steroid hormones in skeletal muscle. *J Steroid Biochem Mol Biol.* 2015; 145:200-5. doi: 10.1016/j.jsbmb.2014.03.009.
9. Ramaswamy S, Weinbauer GF. Endocrine control of spermatogenesis: Role of FSH and LH/testosterone. *Spermatogenesis.* 2014; 4(2):e996025. doi: 10.1080/21565562.2014.996025.
10. Comninos AN, Jayasena CN, Dhillo WS. The relationship between gut and adipose hormones and reproduction. *Hum Reprod Update.* 2014;20:153-74.
11. Godfrey RJ, Madgwick Z, Whyte GP. The exercise-induced growth hormone response in athletes. *Sports Med.* 2003;33:599-613.

12. Zinner C, Wahl P, Achtzehn S, et al. Acute hormonal responses before and after 2 weeks of HIT in well trained junior triathletes. *Int J Sports Med.* 2014;35: 316-22.
13. Hansen M, Kjaer M. Influence of sex and estrogen on musculotendinous protein turnover at rest and after exercise. *Exerc Sport Sci Rev.* 2014;42(4):183-92.
14. Koyun E. The effect of obesity on sperm functions. *Andrology Bulletin.* 2013;15:185-9.
15. Hackney AC, Viru M. Sports physiology and endocrinology (Endurance vs. resistance exercise). In: Vaamonde D, Plessis S, Agarwal A, editors. *Exercise and Human Reproduction*. 1st ed. New York: Springer; 2016. p. 75-92.
16. Zmuda JM, Thompson PD, Winters SJ. Exercise increases serum testosterone and sex hormone-binding globulin levels in older men. *Metabolism.* 1996;45:935-9.
17. Khoo J, Tian HH, Tan B, et al. Comparing effects of low- and high-volume moderate-intensity exercise on sexual function and testosterone in obese men. *J Sex Med*. 2013;10:1823-32.
18. Rietjens R, Stone TM, Montes J, et al. Moderate intensity resistance training significantly elevates testosterone following upper body and lower body bouts when total volume is held constant. *IJKSS.* 2015;3(4):50-5.
19. Kuusi T, Kostiainen E, Vartiainen E, et al. Acute effects of marathon running on levels of serum lipoproteins and androgenic hormones in healthy males. *Metabolism.* 1984;33:527-31.
20. Rahnama N, Bambaeichi E. Chronic effects of exercise on male reproductive hormone profiles. *Cell Mol Biol Lett.* 2004;9(Suppl 2):121-4.
21. Dağlıoğlu Ö, Hazar M. The effect of high speed race load on sudden changes of some hormones. *J Phys Educ Sport Sci.* 2009;11(2):35-40.
22. Hackney AC, Fahrner CL, Gulledge TP. Basal reproductive hormonal profiles are altered in endurance trained men. *J Sports Med Phys Fitness* 1998;38:138-41.
23. Gulledge TP, Hackney AC. Reproducibility of low resting testosterone concentrations in endurance trained men. *Eur J Appl Physiol Occup Physiol.* 1996;73:582-3.
24. Ozen SV. Reproductive hormones and cortisol responses to plyometric training in males. *Biol Sport.* 2012;29:193-7.
25. Zitzmann M, Nieschlag E. Testosterone levels in healthy men and the relation to behavioural and physical characteristics: facts and constructs. *Eur J Endocrinol.* 2001;144:183-97.
26. Wheeler GD, Singh M, Pierce WD, et al. Endurance training decreases serum testosterone levels in men without change in luteinizing hormone pulsatile release. *J Clin Endocrinol Metab.* 1991;72:422-5.
27. Vestergaard ET, Schjørring ME, Kamperis K, et al. The follicle-stimulating hormone (FSH) and luteinizing hormone (LH) response to a gonadotropin-releasing hormone analogue test in healthy prepubertal girls aged 10 months to 6 years. *Eur J Endocrinol.* 2017; 176:747-53.
28. Allen JJ, Herrick SL, Fortune JE. Regulation of steroidogenesis in fetal bovine ovaries: differential effects of LH and FSH. *J Mol Endocrinol.* 2016;57: 275-86.
29. Bieniek JM, Kashanian JA, Deibert CM, et al. Influence of increasing body mass index on semen and reproductive hormonal parameters in a multi-institutional cohort of subfertile men. *Fertil Steril.* 2016;106:1070-5.
30. Thomsen l, Humaidan P, Bungum L, et al. The impact of male overweight on semen quality and outcome of assisted reproduction. *Asian J Androl*. 2014;16: 749-54.
31. Le W, Su SH, Shi LH, et al. Effect of male body mass index on clinical outcomes following assisted reproductive technology: a meta-analysis. *Andrologia.* 2016;48:406-24.